# CHAPTER THREE SOLUTIONS

**3.3** (a) Drawing these to scale and maintaining their respective directions yields a resultant of 5.2 m at an angle of 60° above the $x$ axis.
(b) Maintain the direction of **A**, but reverse the direction of **B** by 180°. The resultant is 3.0 m at an angle of 30° below the $x$ axis.
(c) Maintain the direction of **B**, but reverse the direction of **A**. The resultant is 3.0 m at an angle of 150° with respect to the + $x$ axis.
(d) Maintain the direction of **A**, reverse the direction of **B**, and multiply its magnitude by two. The resultant is 5.2 m at an angle of 60° below the + $x$ axis.

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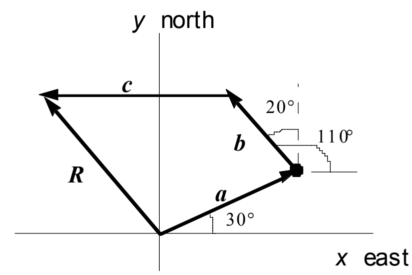
**3.13** Finding the components of the displacements **a**, **b**, and **c** gives:




$a_x$ = acos(30.0°) = +152 km,
$a_y$ = asin(30.0°) = +87.5 km
$b_x$ = bcos(110.0°) = -51.3 km,
$b_y$ = bsin(110.0°) = 141 km
$c_x$ = ccos(180°) = -190 km,
$c_y$ = csin(180°) = 0
Therefore, the components of the position vector **R** are
$R_x = a_x + b_x + c_x = -89.7$ km and $R_y = a_y + b_Y + c_y = +228$ km
The magnitude and direction of the resultant are found from

$$R = \sqrt{(R_x)^2 + (R_y)^2} = 245 \text{ km and } \tan\theta = \frac{R_y}{R_x} = -2.54 \text{ and } \theta = 111.4°.$$

Thus, city C is 245 km at 21.4° west of north from the starting point.

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**3.18** (a) $v_{ox} = 18.0$ m/s, $v_{oy} = 0$. We find the time of fall as $y = v_{oy}t + \frac{1}{2}at^2$, or

$$-50.0 \text{ m} = \frac{1}{2}(-9.80 \text{ m/s}^2)\, t^2, \quad \text{which gives } t = 3.19 \text{ s.}$$

(b) At impact, the horizontal component of velocity is $v_x = v_{ox} = 18.0$ m/s, and the vertical component is

$$v_y = v_{oy} + at = 0 + (-9.80 \text{ m/s}^2)(3.19 \text{ s}) = -31.3 \text{ m/s.}$$

The resultant velocity is found from the pythagorean theorem

$$v = \sqrt{(31.3 \text{ m/s})^2 + (18.0 \text{ m/s})^2} = 36.1 \text{ m/s,}$$

at an angle below the horizontal found as

$\tan\theta = 31.3/18.0$ which yields $\theta = 60.1°$.

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**3.19** We choose our origin at the initial position of the projectile. After 3 s, it is at ground level, $y = -H$. To find $H$, we use $y = v_{oy}t + \frac{1}{2}at^2$.

$$-H = (15 \text{ m/s})(\sin 25°)(3 \text{ s}) + \frac{1}{2}(-9.80 \text{ m/s}^2)(3.0 \text{ s})^2 = -25.1 \text{ m, or } H = 25 \text{ m}$$

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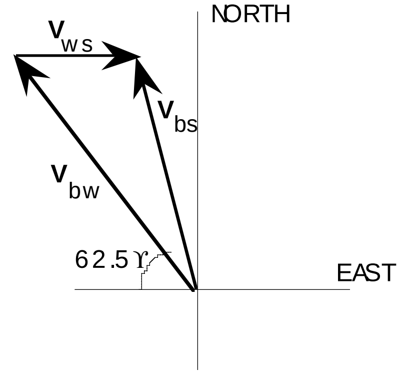
**3.27** $\mathbf{v}_{bw}$ = the velocity of the boat relative to the water.
$\mathbf{v}_{ws}$ = the velocity of the water relative to the shore, and is directed east.
$\mathbf{v}_{bs}$ = the velocity of the boat relative to the shore.
$\mathbf{v}_{bs} = \mathbf{v}_{bw} + \mathbf{v}_{ws}$




The northward components of this equation (where north is across the stream) are

$v_{bs})_N = v_{bw})_N + v_{ws})_N$

$v_{bs})_N$ = (3.30 mi/h) sin 62.5 + 0 = 2.93 mi/h.

And, the time to cross the stream is

$$t = \frac{0.505 \text{ mi}}{2.93 \text{ mi/h}} = 0.172 \text{ h}.$$

The eastward components of the relative velocity equation (where east is parallel to the current) are:

$v_{bs})_E = v_{bw})_E + v_{ws})_E$ = -(3.30 mi/h) cos 62.5 + 1.25 mi/h = -0.274 mi/h.

The distance traveled parallel to the shore =

$(v_{bs})_E\, t$ = (-0.274 mi/h)(0.172 h) = -0.0472 mi = -249 ft = 249 ft upstream.

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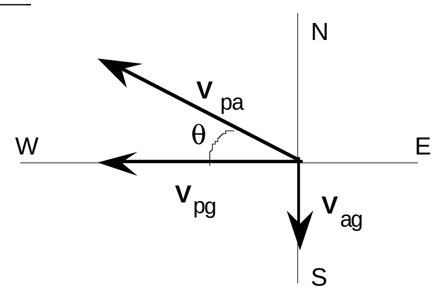
**3.41** (a) First, find the time for the coyote to travel the 70 m to the edge of the cliff. $x = v_o t + \frac{1}{2} a t^2$ gives 70 m = 0 + $\frac{1}{2}$ (15 m/s$^2$) $t^2$, or $t$ = 3.06 s.




The minimum speed of the roadrunner is $v = \frac{x}{t} = \frac{70 \text{ m}}{3.06 \text{ s}} = 23$ m/s.

(b) Find the horizontal velocity of the coyote when he reaches the edge of the cliff.

$$v_x = v_o + at = 0 + (15 \text{ m/s}^2)(3.06 \text{ s}) = 45.8 \text{ m/s}.$$

Now, find the time to drop 100 m vertically starting with $v_{oy}$ = 0.

$$y = v_{oy} t + \frac{1}{2} a t^2 \qquad -100 \text{ m} = 0 + \frac{1}{2} (-9.80 \text{ m/s}^2)\, t^2$$

From which, $t$ = 4.52 s. At this time, the horizontal position can be found from $x = v_o t + \frac{1}{2} a t^2$ as

$$x = (45.8 \text{ m/s})(4.52 \text{ s}) + \frac{1}{2} (15 \text{ m/s}^2)(4.52 \text{ s})^2 = 360 \text{ m}.$$

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**3.47** Note that $\tan\theta_o = h_o/x$ where $h_o$ is the intial target height and $x$ is the horizontal displacement. For the projectile $y_p = v_o \sin\theta_o t - \frac{1}{2} g t^2$, and $x = v_o \cos\theta_o t$ . Combining and eliminating $t$ in first term on right side gives: $y_p = \tan\theta_o x - \frac{1}{2} g t^2$ .

Substituting $h_o/x$ for $\tan\theta_o$ gives: $y_p = h_o - \frac{1}{2} g t^2$ (1)

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For the falling target: $y_t = h_o - \frac{1}{2}\,gt^2$ (2)

From (1) and (2) it can be seen that $y_t = y_p$ at all times $t$.

Thus, the projectile will hit the target.

**ANSWERS TO CONCEPTUAL QUESTIONS**

**3**. (a) no, varying speed means velocity changes also, because speed is the magnitude of the velocity vector. (b) yes, it's possible to move with constant speed, but changing velocity. An example is an object that moves in a circle at constant speed. The velocity vector changes direction, but not length.

**11.** (a) no, motion along a line at constant speed is not accelerated. (b) yes, even though the speed is constant, the direction of the velocity is changing, therefore the motion is accelerated.

**14.** The balls will be closest at the instant the second ball is projected. The first ball will always be going faster than the second ball. There will be a one second time interval between their collisions with the ground. The two move with the same acceleration in the vertical direction. Thus, changing their horizontal velocity can never make them hit at the same time.

**20**. The passenger sees the ball go into the air and come back in the same way he would if he were at rest on the Earth. An observer by the tracks would see the ball follow the path of a projectile. If the train were accelerating, the ball would fall behind the position it would reach in the absence of the acceleration.